National Aeronautics and Space Administration

NASA ACES
V&V Alignment Briefing

Confesor Santiago

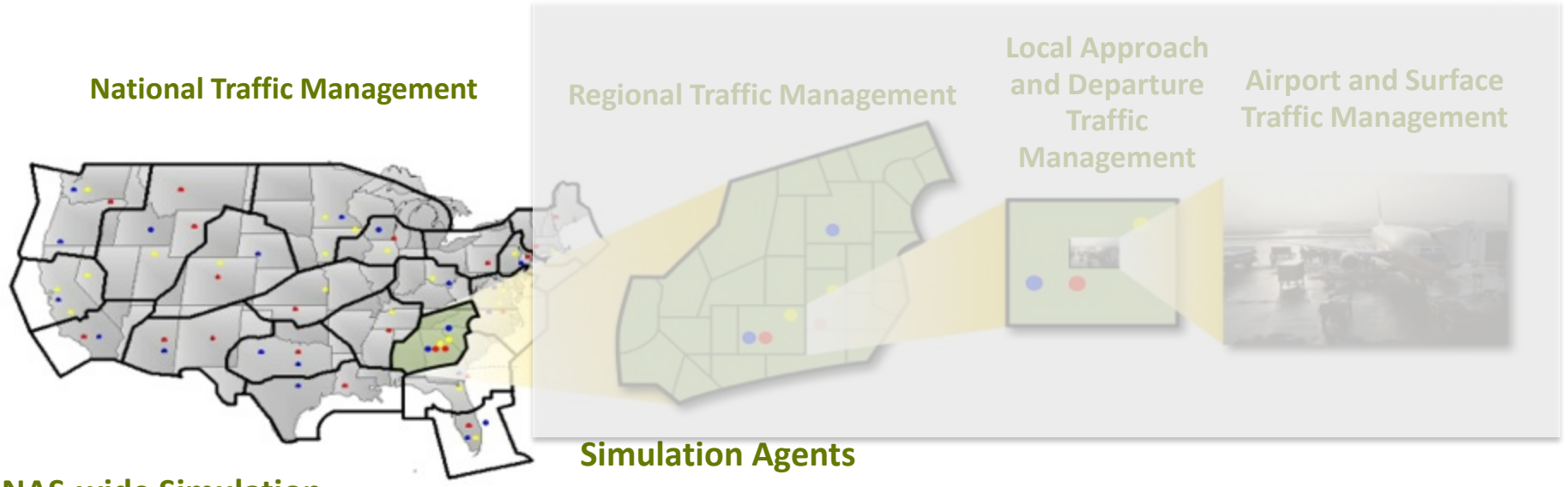
DAA V&V Sub Group

11/17/2015

Goals of Briefing

- To describe the ACES platform.
- To give background on ACES test trajectories and encounters.
- To take inventory on the different models and give background on how they were fabricated.
- To highlight two planned ACEs studies

Modeling and Simulation: ACES



NAS-wide Simulation

- Gate-to-gate simulation of ATM operations
- Full flight schedule with flight plans
- Sector and center models with some airspace procedures

Simulation Agents

- Air traffic controller decision making
- Traffic flow management models
- Individual aircraft characteristics
- IFR Flight Tracks from ASDI data
- VFR Flight Tracks from 84th Squadron RADES data

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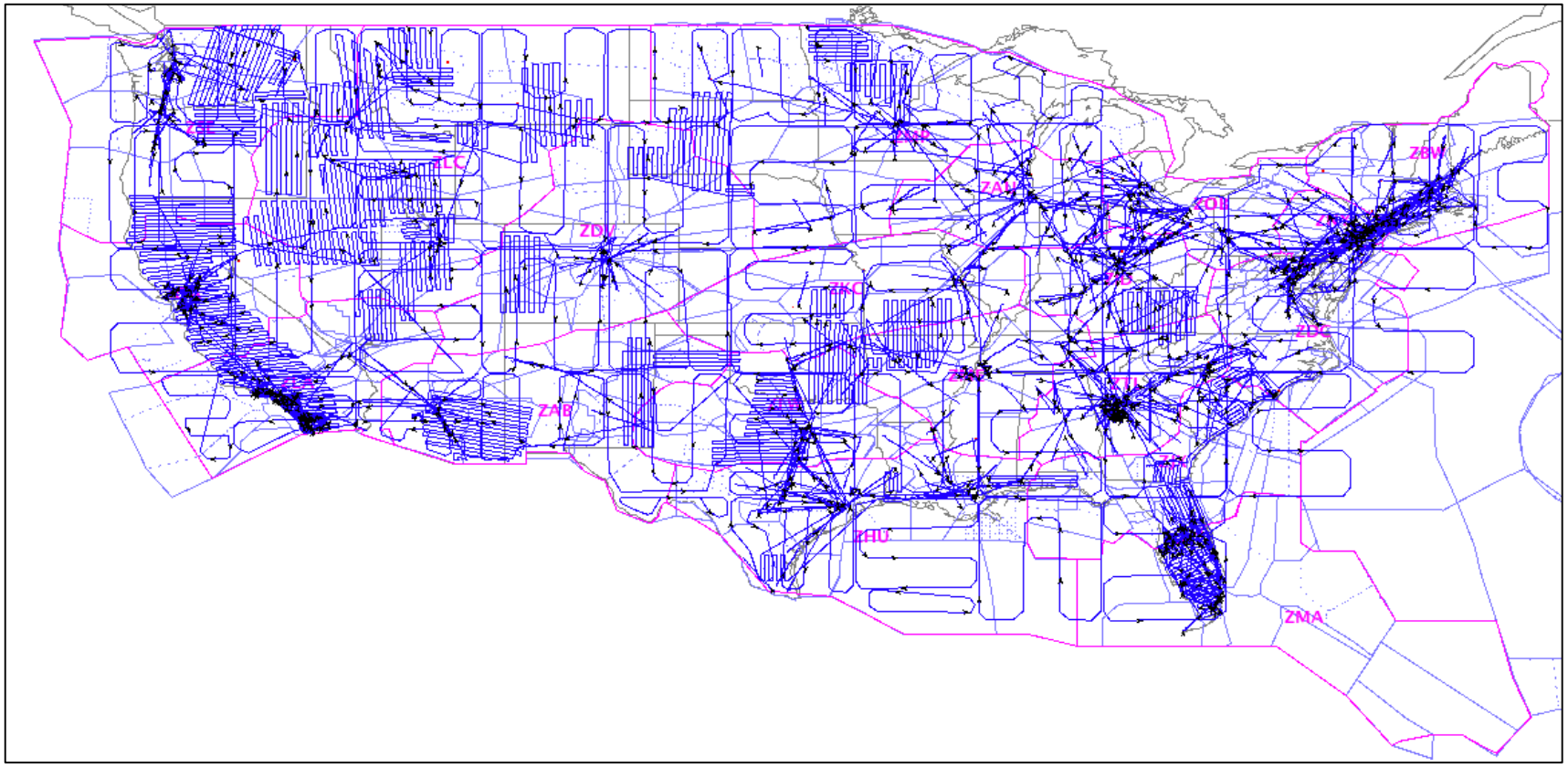
UAS Mission Traffic Scenarios

	UAS group	Duration (per flight)	Flights per day	Cruise Alt.	Flight Pattern
Air Quality Monitoring	Shadow-B	1-4 hrs.	104-1044	4k,5k, and 6k ft AGL	Radiator Grid Pattern
Cargo Transport	Cessna 208	varies	1.4k	2k-16k	Point to Point
Atmospheric Sampling	Global Hawk	1.5-13 hrs.	2352	5k-35k ft AGL	Radiator Grid Pattern
On-demand Remote Air Taxi -Cirrus	Cirrus SR22T	varies	8k	6k-11k	Point to Point
On-demand Remote Air Taxi - Mustang	Cessna Mustang	varies	2k-4k	9k-20k	Point to Point
Strategic Fire Monitoring	Predator-B	20 hrs.	74-324	31k ft MSL	Radiator Grid Pattern
Tactical Fire Monitoring	Shadow-B	1-1.5 hrs.	varies	varies	Circular Loitering Orbit
Flood Inundation Mapping	Aerosonde	1-4 hrs.	varies	4k ft AGL	Radiator Grid Pattern Point to Point
Flow Stream Monitoring	Aerosonde	1-4 hrs.	20-200	4k	Radiator Grid Pattern Point to Point

NAS-wide UAS Mission Profile

- A snapshot of mission profiles: UAS tracks in blue



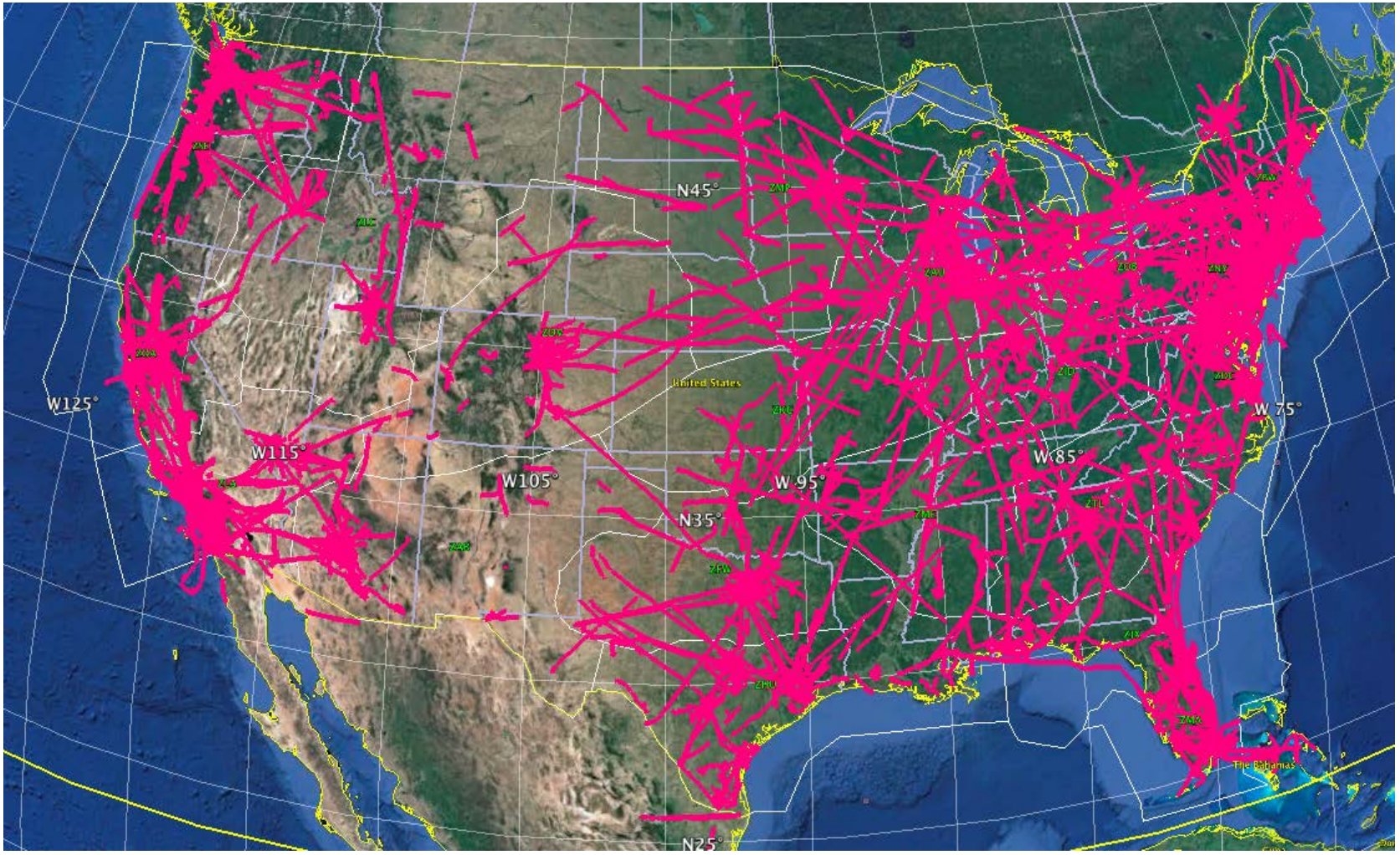
VFR Traffic (courtesy of 84th RADES)

- The 84th Rader Evaluation Squadron (RADES) data were used.
  - The data contain the radar hits collected from hundreds of radar sites in U.S, and each hit provide timestamp, latitude, longitude, Mode 3 code, Mode C code, and others.
  - There is no explicit information that could be used to determine whether radar hits come from IFR flights or VFR flights.

- Criteria for filtering out VFR traffic (for each tracked flight):
  - All tracks are below 18,000 ft,
  - At least one track has the Mode 3 code of 1200,
  - Average speed ranges from 50 knots to 250 knots.

- Non-cooperative VFR radar track currently being processed
  - Using algorithm developed by Honeywell to process non-cooperative VFR tracks and estimates altitude measurements

Cooperative VFR Traffic – July 25, 2013



VFR Traffic Days

- Each simulation run is a single day in the NAS (24 hours starting at 0 UTC)
- The simulation runs were chosen across 3 seasons in 2012 on days with minimal weather impacts
- 6 Days Total
- No IFR intruders

January 2012

Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April 2012

Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

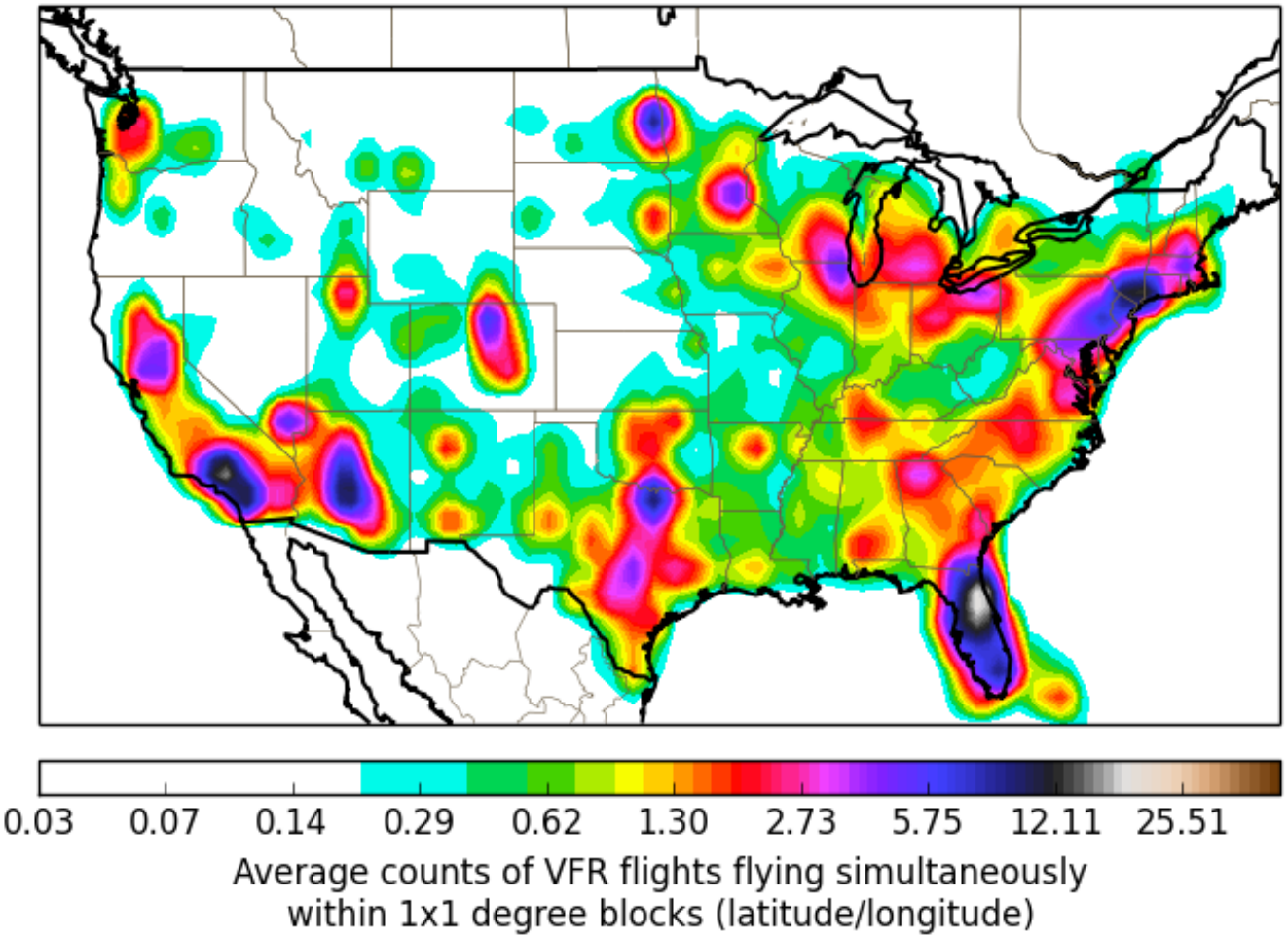
July 2012

Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

October 2012

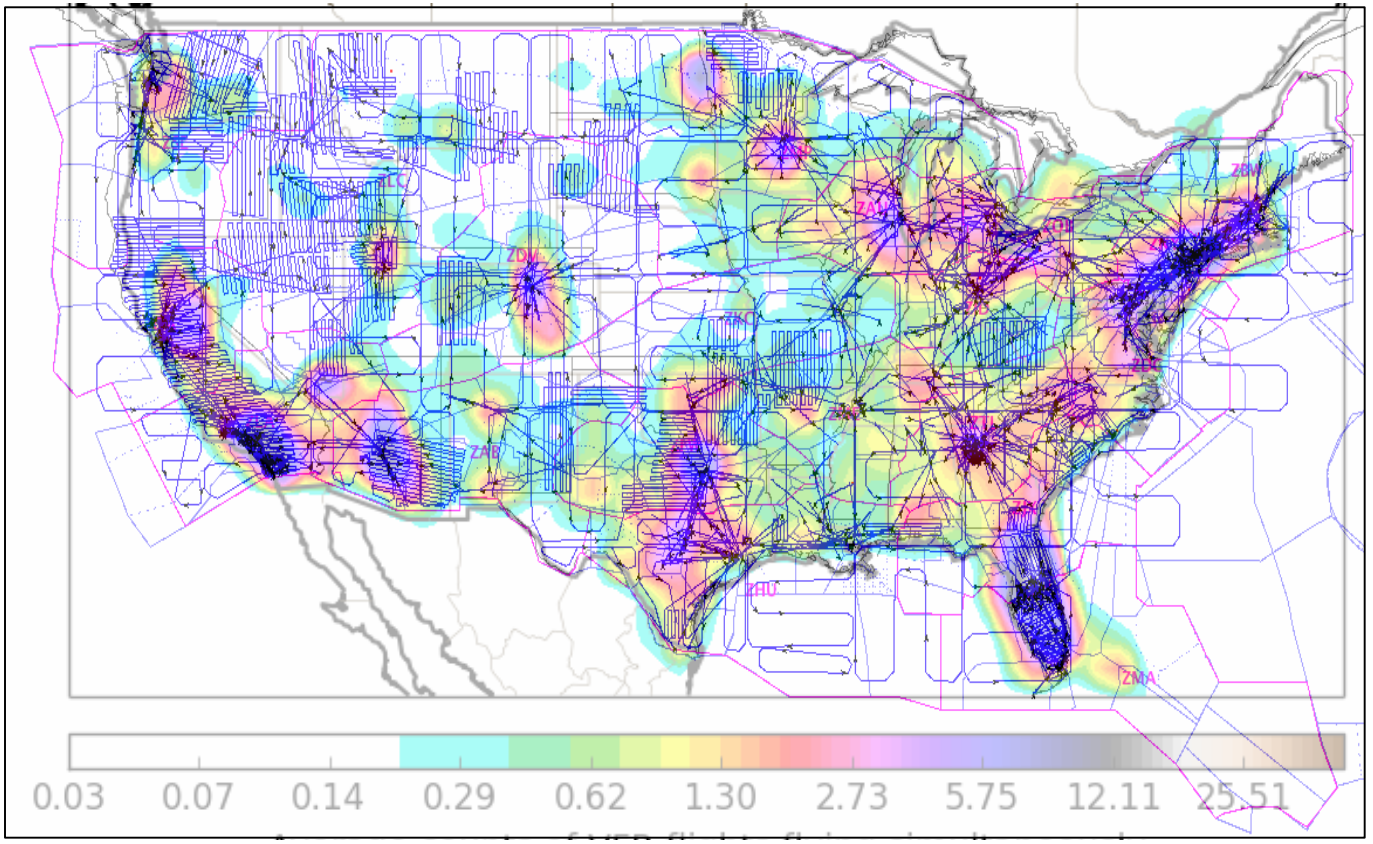
Su	M	Tu	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Processed VFR Traffic: Geographic Flight Density



* Cooperative VFR Flight Profiles from April 4th, 2012

VFR/UAS Traffic Integration



- Results in approximately **2k - 3.5k UAS/VFR encounters** per day
- Variable encounter geometries native to how **VFR operate in the NAS today** vs. the **envisioned paths of UAS's**

VFR Traffic and UAS Surveillance System

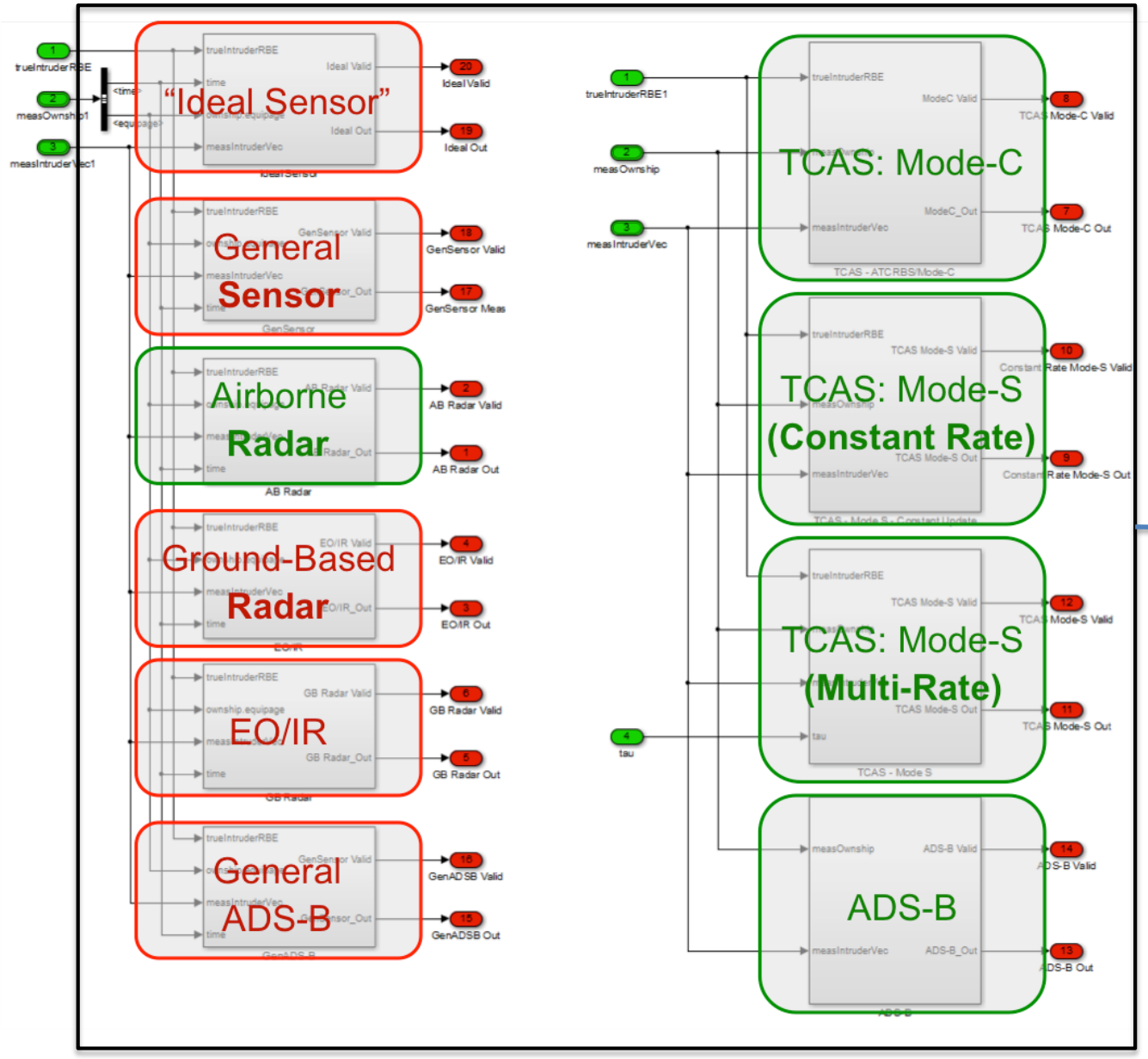
Surveillance Sensor System for UAS

Surveillance System	Surveillance Range (nmi.)	Horizontal FOR (deg.)	Vertical FOR (deg.)	Mean Daily Flight Hours
ADS-B	20	+/- 180	+/- 90	~19000
TCAS (Mode C/S)	14	+/- 180	+/- 90	~4200
Onboard Radar	8	+/- 110	+/- 15	~5000

VFR Traffic Scenario (Based on OSED document)

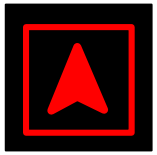
Intruder Aircraft	Transponder Equipage	Percentage	Detection Range (nmi.)
Coop-VFR 1	ADS-B Out	82% of Coop. VFR (OSED: 74%)	20
Coop-VFR 2	Mode C/S Only	18% of Coop. VFR (OSED: 11%)	14
Non-Coop VFR	No Transponder	15~25% of VFR (OSED: 15%)	8

Surveillance Uncertainty



Cooperative with DAA Warning

Cooperative Aircraft		
Symbol	Name	Aural Alert Verbiage
	TCAS RA	"Climb/Descend"
	DAA Warning Alert	"Traffic, Maneuver Now"
	Corrective DAA Alert	"Traffic, Avoid"
	Preventive DAA Alert	"Traffic, Monitor"
	None (Target)	N/A

Non-Cooperative Aircraft		
Symbol	Name	Aural Alert Verbiage
	DAA Warning Alert	"Traffic, Maneuver Now"
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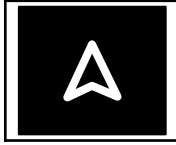
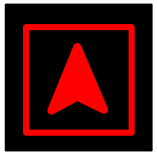
	None (Target)	N/A

Alerting – Cooperative without DAA Warning

Cooperative Aircraft		
Symbol	Name	Aural Alert Verbiage
	TCAS RA	“Climb/Descend”
	Corrective DAA Alert	“Traffic, Avoid”
	Preventive DAA Alert	“Traffic, Monitor”
	None (Target)	N/A

Non-Cooperative Aircraft		
Symbol	Name	Aural Alert Verbiage
	DAA Warning Alert	“Traffic, Maneuver Now”
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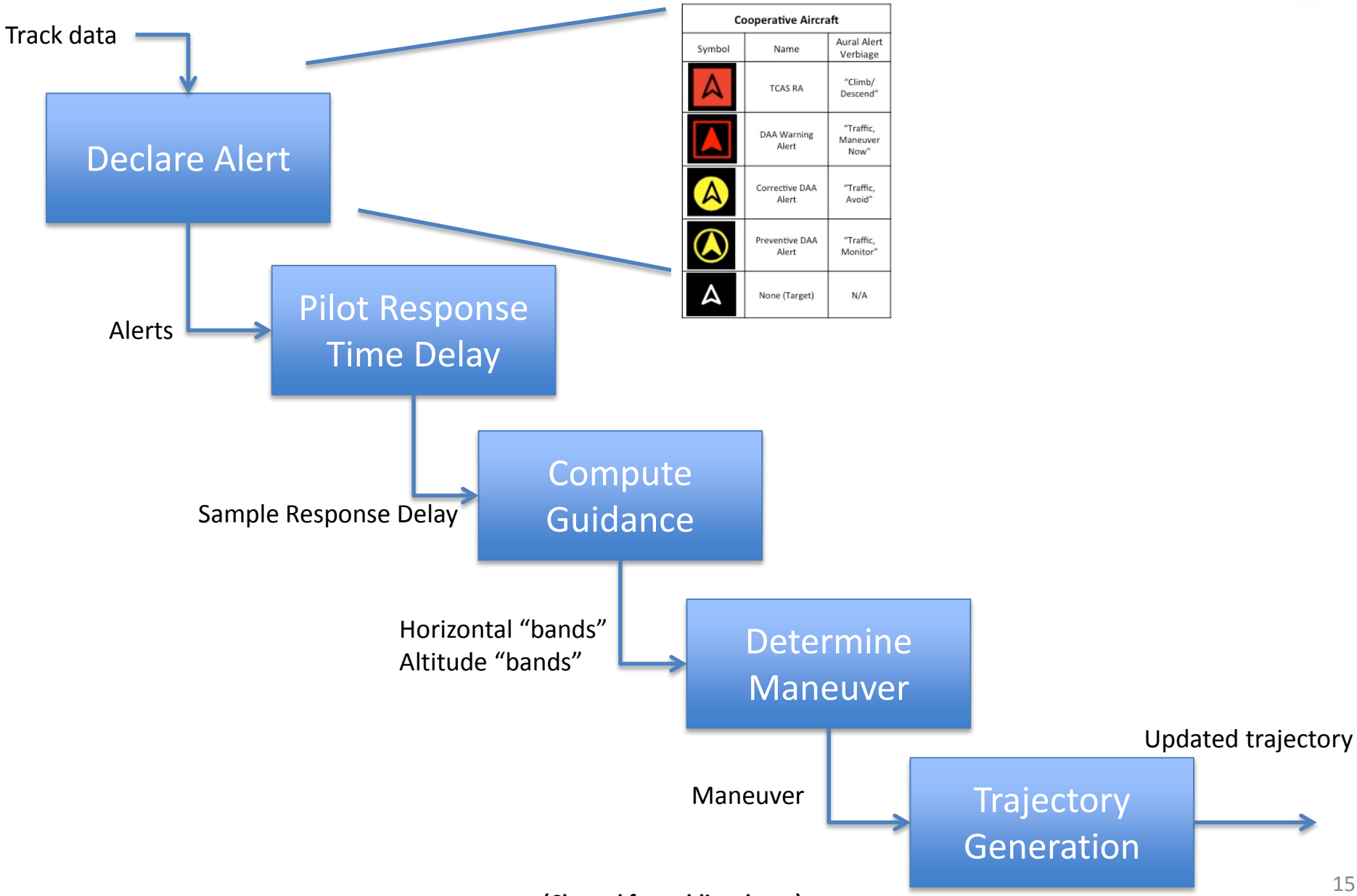
Guidance/Pilot Model



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	None (Target)	N/A

Guidance/Pilot Model

Track data

Declare Alert

Alerts

Pilot Response Time Delay

Sample Response Delay

Compute Guidance

Horizontal “bands”
Altitude “bands”

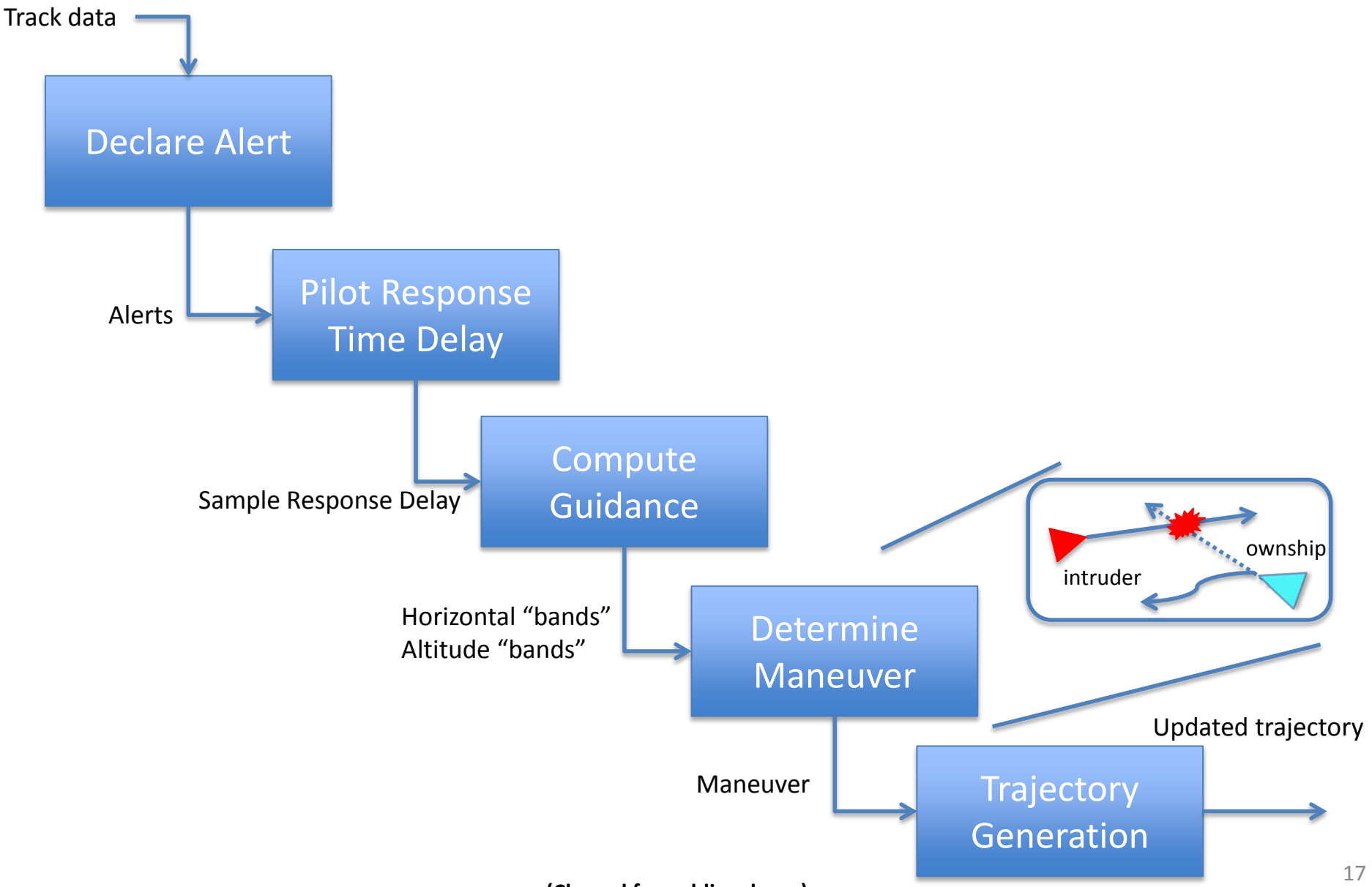
Determine Maneuver

Maneuver

Updated trajectory

Trajectory Generation

Guidance/Pilot Model



Upcoming ACES Studies

1. DAA Tradeoff/Sensitivity ACES Study

2. CA/DAA Interoperability ACES Study

DAA Tradeoff/Sensitivity ACES Study

- Purpose: To collect data to validate DAA surveillance, alerting, and guidance MOPS requirements and to support development of verification tests.

- Methodology: Incorporation of (as many) DAA requirements, operational environment description, and assumptions in ACES and DAA models.
  - VFR (coop and non-coop traffic models)
  - UAS missions
  - MOPS alerting structure
  - OmniBands guidance model with TCAS interoperability concept tested in HSI's "mini-HITL"
  - TCAS RA model
  - Model of CA region for interoperability (i.e. range where altitude guidance shall be inhibited)

- Assumption: We will decompose data and analyze tradeoff/sensitivities between:
  - Surveillance performance
  - Alerting performance
  - Guidance/pilot response time performance
  - *Note: complements end-to-end V&V activities*

- Complements Study 5A

DAA Tradeoff/Sensitivity ACES Study Objectives

- Validate integrated tracker requirements (linkage to Section 2.2.3 – Surveillance Sub-system Requirements)
  - Using ADS-B, Mode C/S, Radar sensor suites to provide tracks for DAA
- Validate Must/Must Not requirements and other alerting req's (linkage to Section 2.2.4 – Guidance Generation Requirements)
  - Did we get them right? Are there gaps?
- Validate DAA guidance thresholds used to provide pilot with maneuver options (linkage to Section 2.2.4 – Guidance Generation Requirements)
  - Is guidance good enough to perform the task, informed by HITL results
- Identify test cases that could be included in verification test procedures (that "stress" sensors, tracker, alerting, or guidance.
  - *Would this be in Section 2.4, or in an Appendix?*

CA/DAA Interoperability ACES Study

- Purpose: To collect data to validate CA/DAA Interoperability MOPS requirements and to support development of verification tests.

- Methodology: Incorporation of (as many) DAA requirements, operational environment description, and assumptions in ACES and DAA models.
  - VFR (coop and non-coop traffic models)
  - UAS missions
  - High-fidelity surveillance models
  - MOPS alerting structure
  - OmniBands guidance model
  - Pilot model

- *Assumption:*
  - *Model TCAS like a black-box, and measure when RA are generated*
  - *Cooperative intruders are equipped with TCAS*
  - *UAS is also equipped with TCAS*

- Complements the data collected in HSI's mini-HITL data collection

Reminder of mini-HITL test objectives

- Recovery/band saturation options
  - Horizontal directive or suggestive guidance options

- Displaying preventive RA as a DAA preventive alert icon; TCAS vertical guidance remains and DAA vertical guidance is consistent with RA
  - Implemented, but not as an experimental variable

- Should the current DAA warning alert be a caution instead while retaining the aural alert?

- Should there be a warning for cooperative targets
  - Recommended to implement DAA warning for cooperatives and have subjective questionnaires to assess comprehension/confusion/etc.

CA/DAA Interoperability ACES Study Objectives

- To validate DAA augmentation concept (that provides interoperability) when a TCAS RA is generated

- To validate the "collision avoidance region" and perform gap analysis to see whether inhibiting altitude level-based guidance and displaying all +/- 500 FPM guidance as unacceptable is too restrictive to perform DAA.
  - Examine different closure speeds, encounter angles, and vertical closure rates
  - Is the CA region too large? Should it have sensitivity levels?

- To validate and identify verification tests CA region, well clear recovery region, and DAA guidance.
  - These boundaries often overlap…needs validation.

- Linkage to the MOPS is Section 2.2.4.4 Collision Avoidance Interoperability and TBD Section on where Well Clear Recovery Guidance requirements will be incorporated into the MOPS

Way Forward

- Align ACES studies schedule with V&V plan
- Iterate on “more specific” objectives - once design is finalized and evaluation criteria is complete
- Discussion on what’s required from ACES V&V test matrix (what Dave requested 40 hours of work was needed)
- Provide feedback so I can prepare for a follow-on tag up
- Anything else???

Questions

Or

Comments